Energy Deposition in the Target System of a Muon Collider/Neutrino Factory

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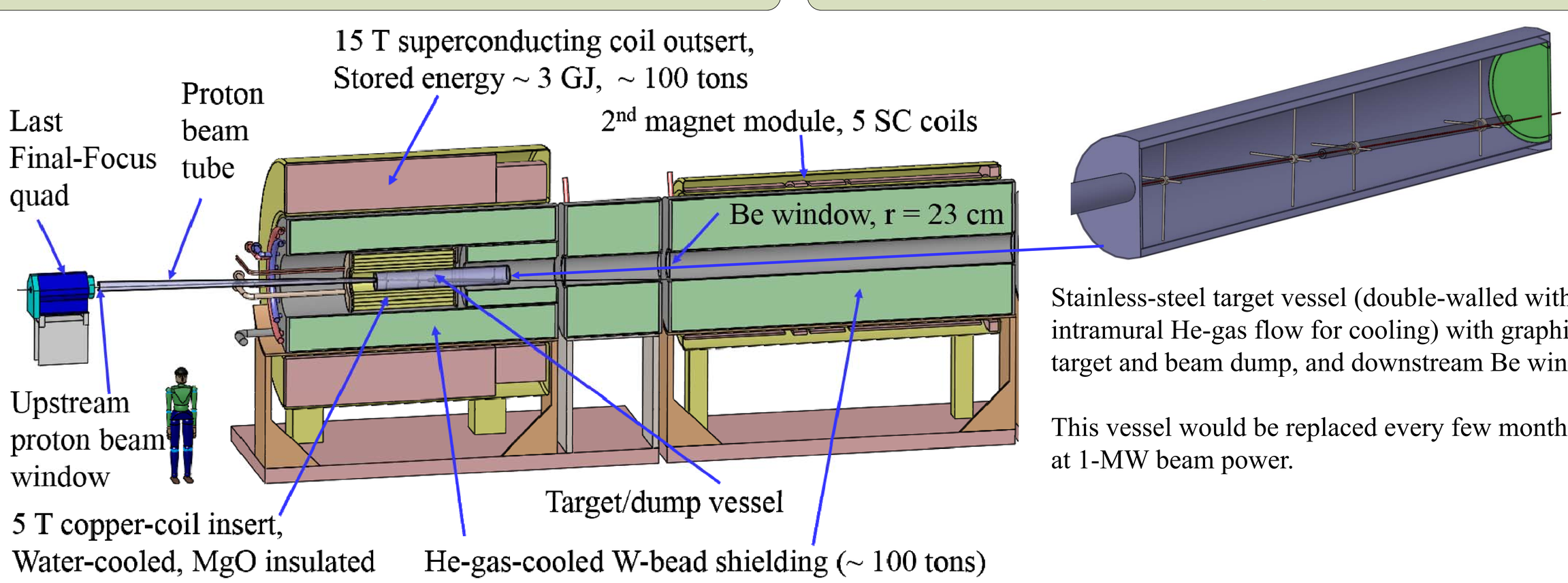
Target System Concept

- Graphite target ($\rho \sim 1.8$ g/cm^3), radiation cooled.
- Target inside high-field solenoid magnet (20 T) that collects both $\mu^{\pm}$.
- Target and proton beam tilted with respect to magnetic axis.
- Superconducting magnet coils shielded by He-gas-cooled W beads.
- Proton beam dump via a graphite rod just downstream of the target.

Energy/Power Deposition Issues

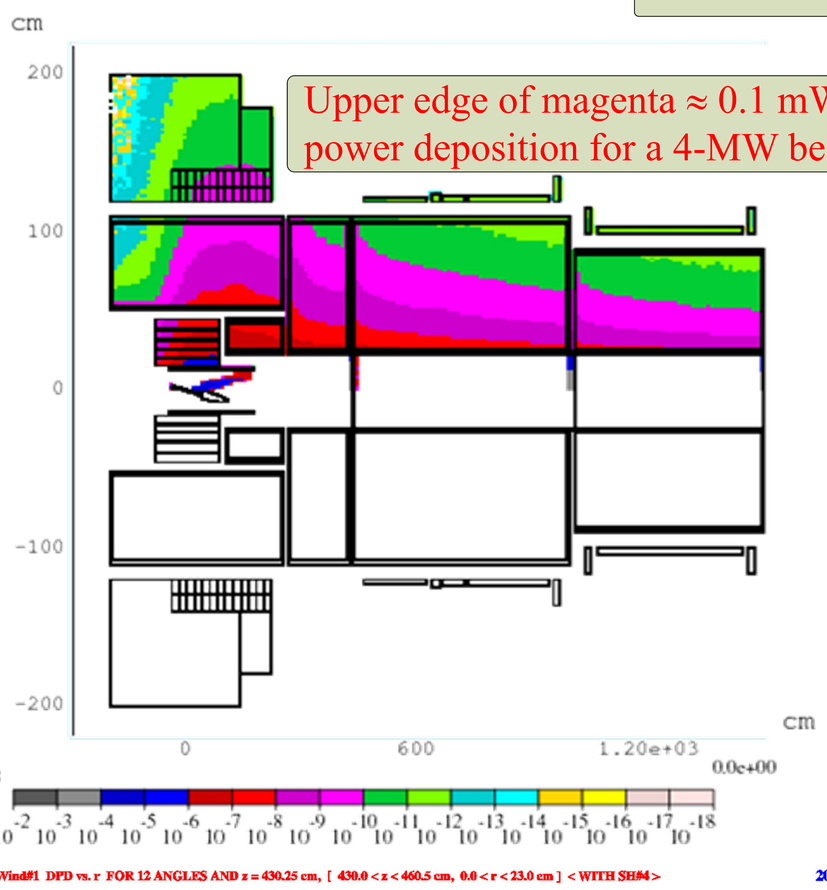
- Radiation damage to superconducting coils (particularly to organic insulation) limits the power deposition in the coils to 0.1 mW/g, for a 10-year lifetime of 10^7 sec/yr.
- Transient heating of the target by the pulsed proton beam induces "thermal shock" that can crack the target.



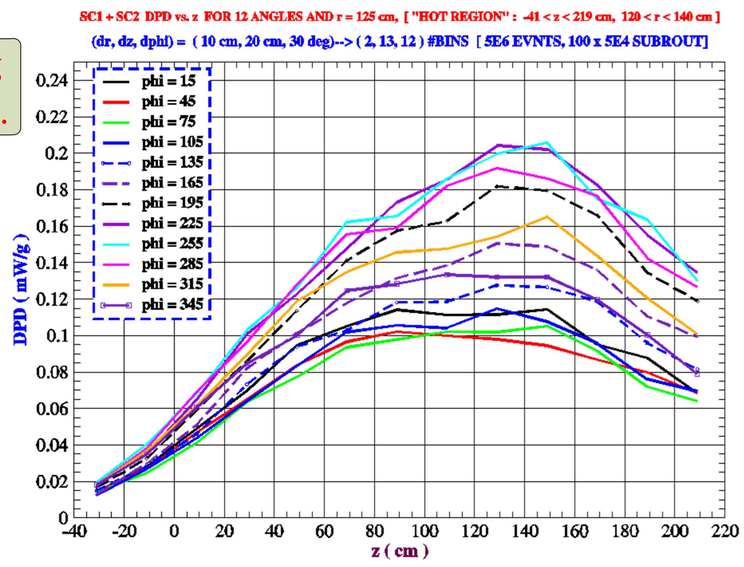
Stainless-steel target vessel (double-walled with intramural He-gas flow for cooling) with graphite target and beam dump, and downstream Be window.

This vessel would be replaced every few months at 1-MW beam power.

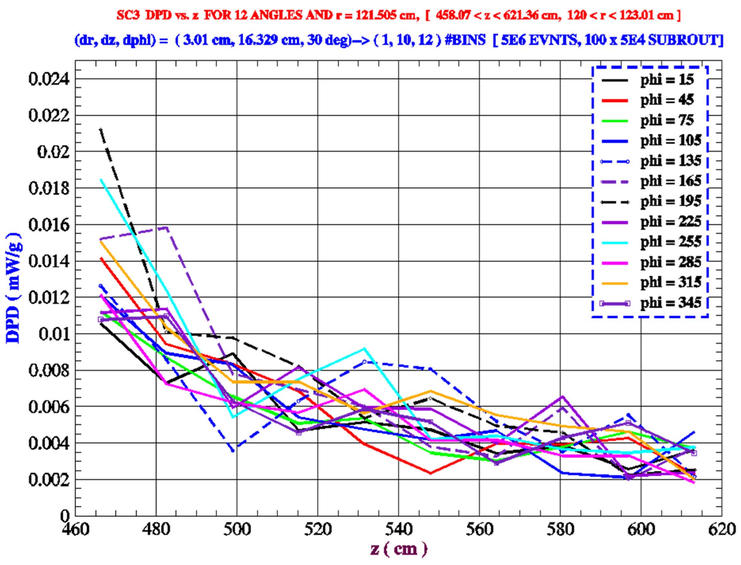
Power Deposition in Target System Components



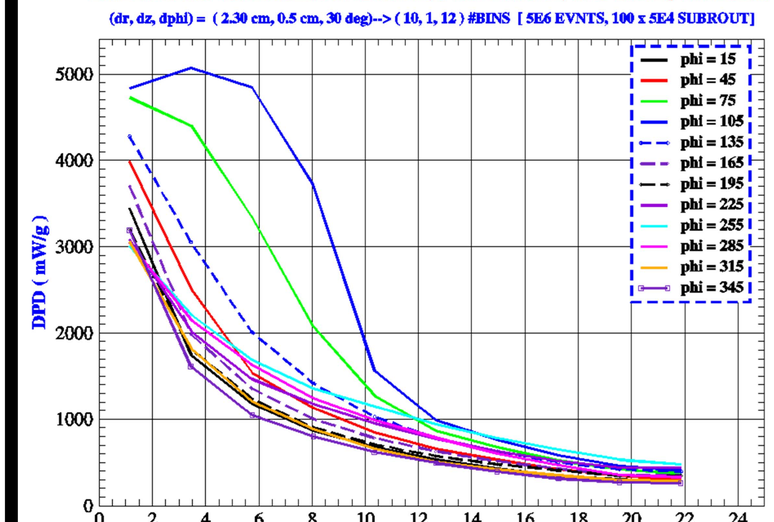
Upper edge of magenta ≈ 0.1 mW/g power deposition for a 4-MW beam.



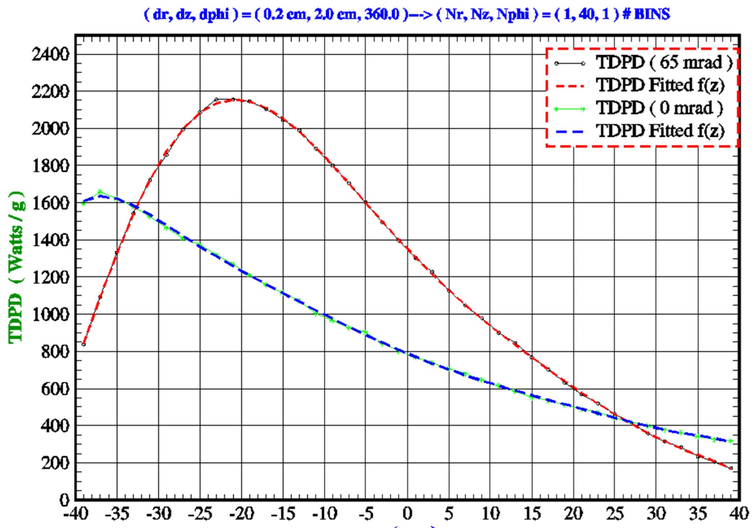
Power deposition in SC coils 1 and 2 exceeds 0.1 mW/g for 4-MW beam power, but is OK for 2-MW beam power.



Power deposition in SC coil 3 exceeds 0.1 mW/g for 4-MW beam power, but is OK for 2-MW beam power.



If secondary beamline is not in air, need beam windows at ends of each shield module. Power deposition in such windows would be significant ⇒ Double windows with He-gas cooling (which may degrade the beam).



Power deposition in the graphite target is large, but appears to be such that the "thermal shock" is sustainable for beam powers up to 2-4 MW.

Conclusions

Massive shielding of the superconducting coils by W-beads (cooled by He-gas flow) can protect the coils from radiation damage, but this implies large coil radii and very large stored magnetic energy.

If the Decay Channel downstream of the Target System is not in air, each magnet module in this Channel requires two (double-wall) beam windows, whose effect on the secondary muon be is not negligible.

The energy deposition in the target is close to the limit for shattering by "thermal shock", particularly for a Muon Collider with 15-Hz rep rate (compared to 60 Hz for a Neutrino Factory). More study is needed here.